



NAMIBIA UNIVERSITY
OF SCIENCE AND TECHNOLOGY

Systems Simulation Modelling (SSM710S)

Mrs Justina N Ambuga

Office G29, Ground Floor, Old Engineering Building

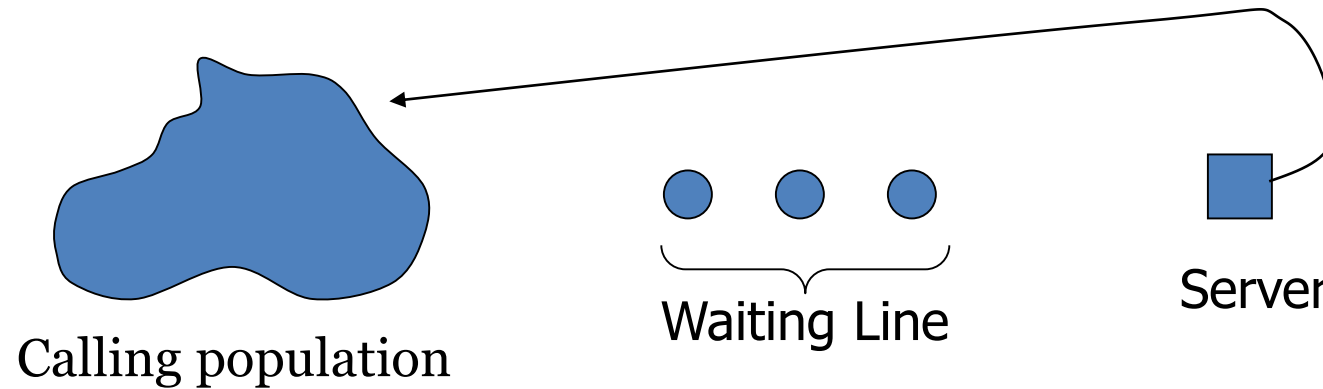
Email: jambuga@nust.na

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3. Simulation of Queuing Systems

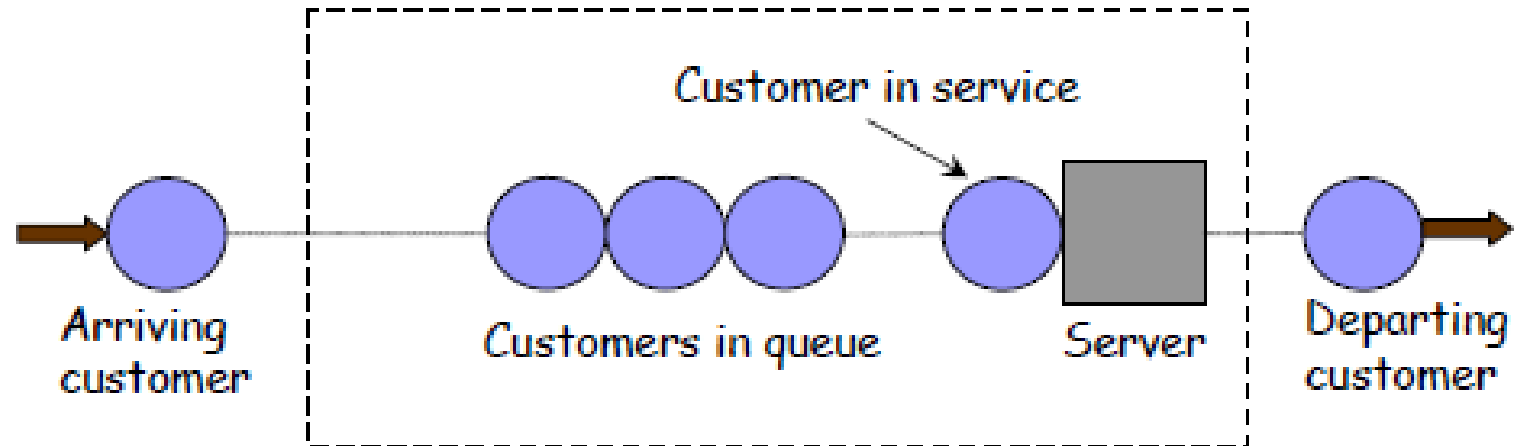
Simulation of Queuing Systems



- A queuing system is described by its calling population, the nature of the arrivals, the service mechanism, the system capacity, and the queuing discipline.

Simulation of Queuing Systems

Single-server queuing system

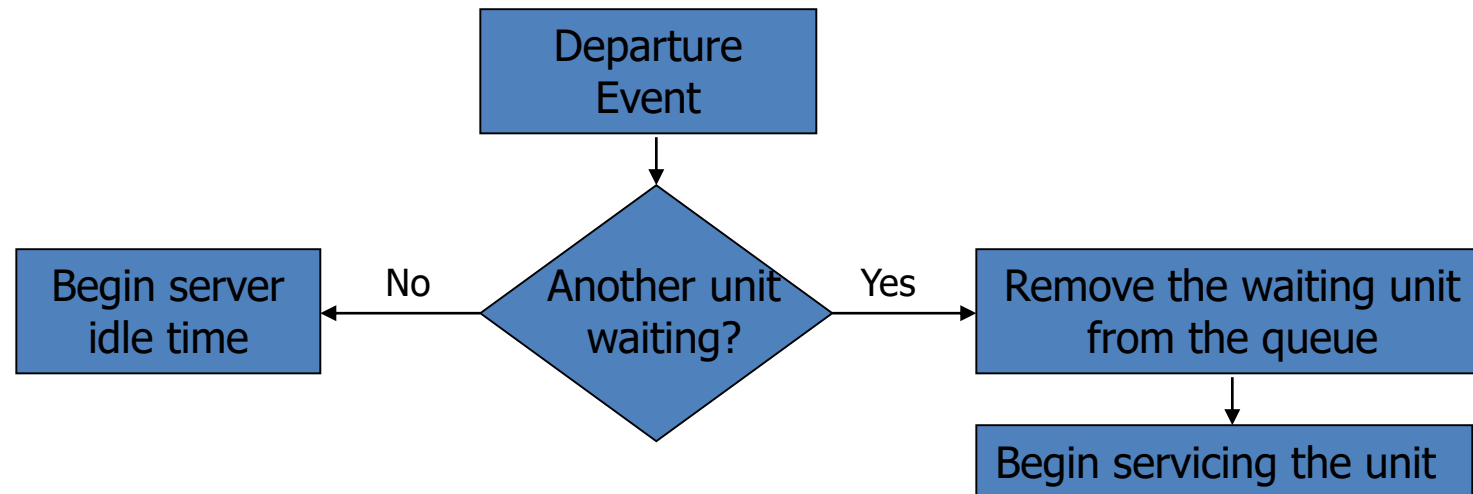


- What are the events?

Simulation of Queuing Systems

Service completion event

- If a unit has just completed service, the simulation proceeds in the manner shown in the flow diagram. (*NB*: the server has only two possible states : it is either busy or idle.)

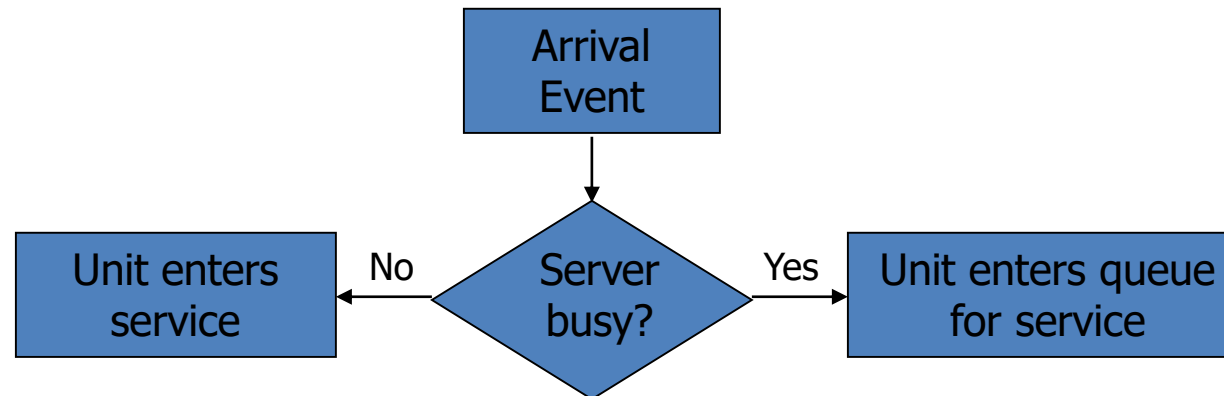


Service-just-completed flow diagram

Simulation of Queuing Systems

Arrival event

- The arrival event occurs when a unit enters the system.
 - The unit may find the server either idle or busy.
 - Idle : the unit begins service immediately
 - Busy : the unit enters the queue for the server.



Unit-entering-system flow diagram

Simulation of Queueing Systems

		Queue status	
		Not empty	Empty
Server status	Busy	Enter queue	Enter queue
	Idle	Impossible	Enter service

Potential unit actions upon arrival

		Queue status	
		Not empty	Empty
Server outcomes	Busy	YES	Impossible
	Idle	Impossible	YES

Server outcomes after service completion

Simulation of Queueing Systems

- Simulation of queueing systems generally require the maintenance of an event list for determining what happens next.
- Simulation clock times **for arrivals and departures** are computed in a simulation table customized for each problem.
- In simulation, events usually occur at random times, the randomness imitating uncertainty in real life.
- Random numbers are distributed uniformly and independently on the interval (0,1).
- Random digits are uniformly distributed on the set {0, 1, 2, ... , 9}.
- The proper number of digits is dictated by the accuracy of the data being used for input purposes.

Simulation of Queueing Systems

- Pseudo-random numbers : numbers are generated using a procedure → detailed in Chapter 7.
- **Example:** Table 2.2. Inter-arrival and Clock Times
 - Assume that the times between arrivals were generated by rolling a die five times and recording the up face.

Table 2.2 Interarrival and Clock Times

<i>Customer</i>	<i>Interarrival Time</i>	<i>Arrival Time on Clock</i>
1	—	0
2	2	2
3	4	6
4	1	7
5	2	9
6	6	15

Simulation of Queueing Systems

Example

- Table 2.3. Service Times
 - Assuming that all four values are equally likely to occur, these values could have been generated by placing the numbers one through four on chips and drawing the chips from a hat with replacement, being sure to record the numbers selected.
 - The only possible service times are one, two, three, and four time units.

Table 2.3 Service Times

<i>Customer</i>	<i>Service Time</i>
1	2
2	1
3	3
4	2
5	1
6	4

Simulation of Queueing Systems

Example

- The inter-arrival times and service times must be meshed to simulate the single-channel queueing system.
- Table 2.4 was designed specifically for a single-channel queue which serves customers on a first-in, first-out (FIFO) basis.

Table 2.4 Simulation Table Emphasizing Clock Times

A	B	C	D	E
<i>Customer</i>	<i>Arrival</i>	<i>Time Service</i>	<i>Service</i>	<i>Time Service</i>
<i>Number</i>	<i>Time</i>	<i>Begins</i>	<i>Time</i>	<i>Ends</i>
	<i>(Clock)</i>	<i>(Clock)</i>	<i>(Duration)</i>	<i>(Clock)</i>
1	0	0	2	2
2	2	2	1	3
3	6	6	3	9
4	7	9	2	11
5	9	11	1	12
6	15	15	4	19

Simulation of Queueing Systems

Table 2.5 Chronological
Ordering of
Events

<i>Event Type</i>	<i>Customer Number</i>	<i>Clock Time</i>
Arrival	1	0
Departure	1	2
Arrival	2	2
Departure	2	3
Arrival	3	6
Arrival	4	7
Departure	3	9
Arrival	5	9
Departure	4	11
Departure	5	12
Arrival	6	15
Departure	6	19

- Table 2.4 keeps track of the clock time at which each event occurs.
- The occurrence of the two types of events (arrival and departure event) in chronological order is shown in Table 2.5 and Figure 2.6.
- Figure 2.6 is a visual image of the event listing of Table 2.5.
- The chronological ordering of events is the basis of the approach to discrete-event simulation.

Simulation of Queueing Systems

- Figure 2.6 depicts the number of customers in the system at the various clock times.

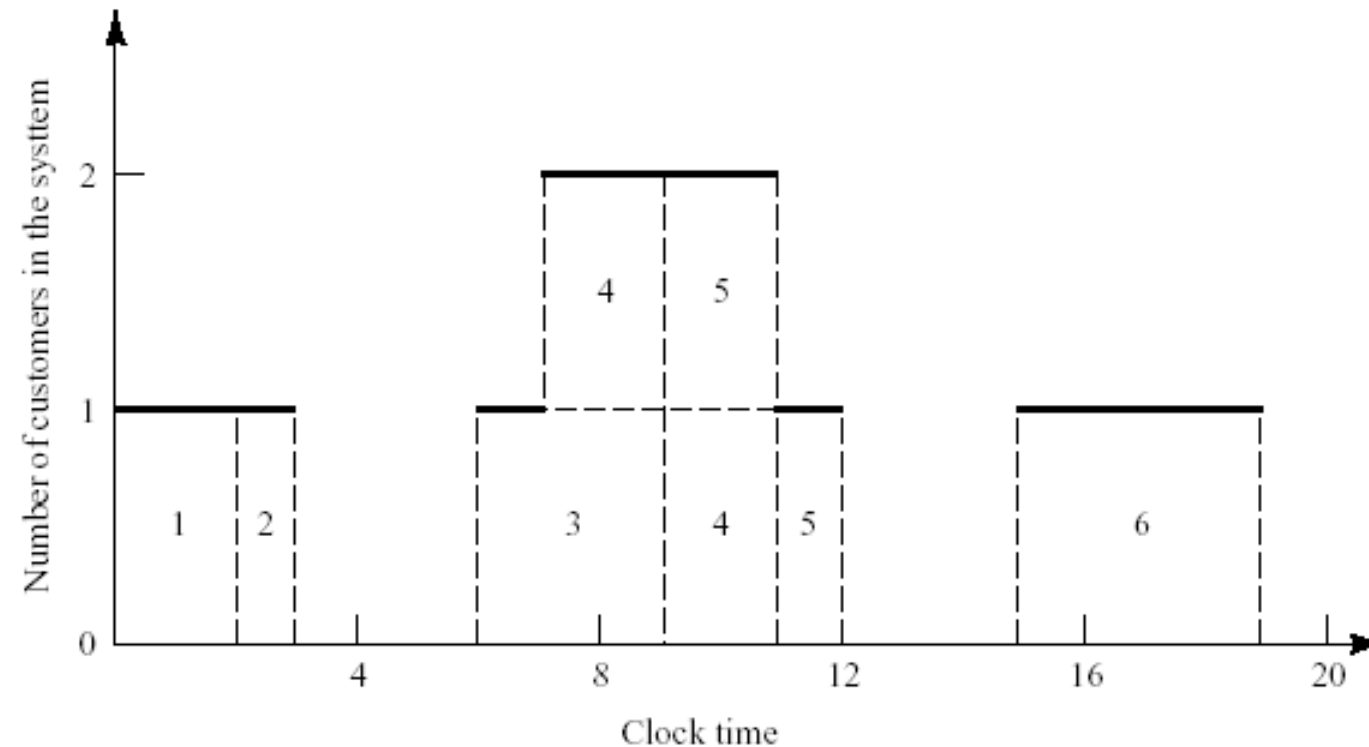


Figure 2.6 Number of customers in the system.

Performance Measures

Typical Performance Measures

1. Average waiting time for a customer
2. Average service time
3. Average time between arrivals
4. Average time customer spends in the system
5. Probability that a customer has to wait in the queue
6. Probability of idle server
7. Probability of server busy = $1 - \text{prob of idle server}$



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General Discussion, Questions, Comments, and Suggestions





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The end!
Thank You for Your Attention